PB-214 874

# HEALTH AND SAFETY IN THE ATOMIC ERA

Conrad P. Straub

Robert A. Taft Sanitary Engineering Center
Cincinnati, Ohio

1958

DISTRIBUTED BY:

NTIS

National Technical Information Service
U. S. DEPARTMENT OF COMMERCE
5285 Port Royal Road, Springfield Va. 22151

PB 214 874

LIBRARY
SANITARY ENGINEERING CENTER
CINCINNATI, OHIO

# HEALTH AND SAFETY IN THE ATOMIC ERA

By

Conrad P. Straub, Ph. D.

Sponsored by the New Jersey Chamber of Commerce,

held at Newark, New Jersey, October 2, 1958,

for publication in the proceedings of the New Jersey Atomic Energy Symposium.

U. S. Department of Health, Education, and Welfare

Public Health Service

Bureau of State Services

Division of Radiological Health

Robert A. Taft Sanitary Engineering Center

Cincinnati 26, Ohio

Reproduced by
NATIONAL TECHNICAL
INFORMATION SERVICE
U S Department of Commerce
Springfield VA 22151

# HEALTH AND SAFETY IN THE ATOMIC ERA

The continued development and use of nuclear energy has been accompanied by the release of a wide variety of radioactive materials into the environment. In the past, naturally occuring radionuclides and cosmic radiation were essentially the sole sources of such contamination. At present, however, radioactive contamination can result from multiple sources including uranium and thorium ore mining and concentration plants, fuel fabrication facilities, reactor installations -- both fixed and mobile, fuel reprocessing plants, beneficial applications of radioisotopes in medicine, research, and industry, and fallout from nuclear tests.

Radioactive materials from any of these operations can lead to the direct exposure of the occupational worker and the general population, or to contamination of various segments of the environment. Although the responsibility for the control of radioactive pollutants is with the operator of the facility involved, particularly as it relates to the exposure of the worker during normal and emergency operations and the general population during accidental release of radioactive materials, local and national health agencies are necessarily interested in the wide scale public health implications of such releases.

Maximum Permissible Exposure

Ionizing radiations result from the disintegration of unstable nuclei. These radiations are damaging to living tissue. Irradiation may originate from an external source or from radioactive materials within the body. In the case of an external source, if there is no shielding, the body as a whole may be exposed to the radiation. With shielding, it is possible to subject specific portions of the body to ionizing radiations; as for example, in the x-ray treatment of a tumor.

Radiation effects from radioactive materials within the body depend upon several factors: the quantity of radioactive material absorbed, the type of radiation, the organ or organs of localization, the rate of excretion, and the half-life or rate of decay of the material. These factors and others are considered in calculating the maximum permissible concentration for each radioisotope in water or air for occupational exposure.

As pointed out earlier, exposure may be due to internal sources which are deposited in the body following ingestion, inhalation, or puncture, or from external sources. Available instrumentation may be used to measure external radiation; but the dose due to internally deposited materials is much more difficult to measure. Recently, whole body counters have been developed which can measure the amount of gamma emitting radionuclides in the body.

One measure of gaging the significance of environmental contamination is in relation to the maximum permissible concentration values recommended by the International Commission on Radiological Protection (1) or the National Committee on Radiation Protection (2) for many radionuclides in water and air. The AEC has recently suggested the applicability of the water MPC values to food substances following a change in units from microcuries per milliliter to microcuries per gram wet weight (3). Furthermore, the recommendation has been made that the permissible occupational levels be reduced by a factor ranging from 10 to 100 to apply to the general population because of the potential genetic effects arising from the radiation exposure of large segments of the pupulation. The MPC values have been calculated on the basis of continuous intake of, and exposure to, the radionuclide in question for long periods of time ranging from 40 to 70 years.

Surveillance Activities

Before the extent of contamination may be determined, a system of monitoring stations must be established to measure the levels of radioactivity in the environmental media of interest and to note the changes taking place in these levels. Two approaches may be used to environmental monitoring or surveillance -- gross activity or specific radionuclide analyses. Measurement of gross activity will serve as a basis for routine control in nuclear energy establishments and to indicate accidental release of radioactivity in plant operations. It will also be

helpful in following the movement of radioactive clouds resulting from nuclear detonations when such detonations take place in the open and in estimating the external dose contributed by such releases. For an evaluation of low level hazards, specific radionuclide activity must generally be determined.

The Atomic Energy Commission, usually in conjunction with other federal and foreign agencies, operates various networks to define the fallout problem. For example, the Lamont Laboratories (4) in New York, New York, receive samples of human and animal bone from all over the world for strontium-90 assay. The Health and Safety Laboratory, AEC, in cooperation with the U. S. Department of Agriculture and others, receives milk, vegetation, soil, and fallout samples from many states and countries (5). The U. S. Weather Bureau collects fallout samples from 92 stations and AEC contractors from 11 stations.

The U. S. Public Health Service conducts the off-site radiological safety activities for the AEC during continental weapons tests at the Nevada Test Site and for Joint Task Force-7 at the Pacific Proving Grounds. Included in the off-site monitoring program is the National Radiation Surveillance Network consisting of 45 stations, which, with the cooperation of State and local health agencies, submit daily air filter samples to the central laboratory in the Division of Radiological Health, Washington, D. C. In addition 37 of the 45 stations also submit rain samples for gross activity measurements.

Three national networks are operated through the Robert A. Taft Sanitary Engineering Center, PHS, Cincinnati, in cooperation with state and municipal agencies. These include the National Air Sampling Network which comprises 114 urban and 47 non-urban stations from which 24-hour samples of air particulates are collected at least bi-weekly and checked for radioactivity in addition to other air contaminants; the Basic Data Water Quality Network from which weekly samples from 40 stations on the principal U. S. streams are collected and assayed for gross beta and, in some cases, alpha activity; and a National Milk Surveillance Network, which was begun in 1957 with samples from 5 milksheds: Sacramento, California; Salt Lake City, Utah; St. Louis, Missouri; Cincinnati, Ohio; and New York, New York. These samples were assayed for total strontium, strontium-90, strontium-89, barium-140, cesium-137, and iodine-131. Recently, five milksheds have been added to the program: Atlanta, Georgia; Austin, Texas; Chicago, Illinois; Fargo, North Dakota; and Spokane, Washington.

At Cincinnati gross and specific radionuclide levels are determined also in rainfall, cistern waters, vegetation, various other food materials, as well as natural radon and thoron daughter products.

This array of networks operated by Federal and State agencies is supplemented by a few independent and comprehensive programs by some states and a few municipalities. The participation of many more states would be desirable to assist in the evaluation of the impact of radioactive contamination on our complex agrarian community.

## Sources of Radioactivity

At this time, it may be well to review the major sources which contribute radioactive materials to the environment.

## Ore Production and Processing

In mining uranium, as in any mining operation, care must be taken to protect the workers from exposure to dusts, and from prolonged contact with the ore (radon inhalation). There will be some losses of material in transport and during storage, but in most cases the levels of radioactivity will be low. Gross alpha or beta-gamma measurements with suitable instrumentation will provide information on potential external radiation hazards. Analyses for radon will indicate the extent of exposure to this source. Where uranium ores are stored in the open, it may be desirable to check near-by streams for levels of soluble radium which may have been leached from these accumulations during storage. Vegetation and soil in the area may be checked for radium, since this is the most hazardous radionuclide.

During processing of the ores for uranium recovery, liquid wastes may be discharged which contain uranium, radium, and the daughter products of these elements. In a few cases, the tailings are discharged directly to the stream, but in most instances they are stored and the wastes are discharged to tailings ponds where settling of most of the suspended matter can take place. The tailings ponds discharge into near-by water

courses. Experience has shown that radium levels in streams below these plants are somewhat higher than those upstream. It is necessary, therefore, to measure the radium levels in water above and below the plant site, as well as to measure the activity in the bottom muds and the associated stream biota. Analyses of muds below uranium processing plants is a well known procedure for control of such operations. Where these stream waters are used for irrigation, plant uptake may be of consequence and analyses should be made for radium and uranium in soil samples and vegetation which serves as a source of animal and human food.

In all cases, useful data may be obtained by the measurement of gross activities associated with particulate matter.

Fuel Production

The processing of prepared uranium ore for the production of $UO_2$, $UF_4$, or $UF_6$ presents the ordinary problems associated with chemical industries using toxic solvents and extracting solutions and complicated reactors. Mists and fumes must be controlled and contaminants removed by scrubbing, filtration, or other means to prevent atmospheric contamination.

Refined uranium metal, an end product of chemical processing, is fabricated for reactor fuel. During fabrication, which includes such operations as rolling, extruding, machining, and other metallurgical treatments, fumes of uranium oxide may be given off as atmospheric

contaminants. Water used in cooling or clean-up contains uranium dusts and chips but these can be removed easily and need not contaminate any water-way or sewer system.

Environmental contamination may be controlled by minimizing the release of atmospheric contaminants and by providing facilities for the removal of uranium dust and chips from liquid wastes prior to their discharge.

Reactor Installations

Most older reactors are of the single flow-through coolant type, the coolants being air or water. As a result, relatively large volumes of contaminated air or water are discharged. To minimize the formation of induced activity, the coolant is pretreated to remove most particulate matter. Before release to the environment, the air is filtered to remove particulate activity and the water is stored to permit decay of the short-lived radionuclides formed in or picked up in passing through the reactor. Power and many experimental reactors generally operate on a closed coolant cycle with passage of the coolant through ion exchange columns or other treatment devices for the removal of radioactivity.

With proper operation, the amounts of radioactivity discharged from single pass -- or circulating -- type reactors, according to calculations, should be quite small, and should be at or well below the MPC values. Local conditions will govern the release of radionuclides.

Coolant air, after passing through the reactor and treatment to remove particulate matter, is usually discharged through stacks for dispersion of the argon-41 produced. Monitoring may include analyses to determine the levels of this radionuclide during dispersion under various meteorological conditions.

Gross or radionuclide activity may be measured prior to or during release of wastes into streams and will include measurement of radioactivity in reactor coolant water (where single pass cooling is employed as at Hanford), fuel element canal storage water, wastes from laboratory areas and laundries, and washings from decontamination pads or cells. Because of deposition, adsorption, and/or ion exchange in the stream environment, bottom sediments must be examined. Similarly, because of adsorption or metabolism, there is a need for determining the levels of accumulation in plankton, fish, vegetation, and animals.

This type of minitoring has resulted in the voluntary reduction of maximum permissible levels of discharge into the stream environment by Hanford of the following radionuclides (6): Ru-106 from 0.1 to $10^{-3}$ $\mu$c/ml (the ICRP values (1) for this nuclide are given as 0.1 $\mu$c/ml for the kidney and $10^{-4}$ $\mu$c/ml for the GI tract), P-32 from $2 \times 10^{-4}$ to $3 \times 10^{-7}$ $\mu$c/ml, Na-24 from $8 \times 10^{-3}$ to $2 \times 10^{-6}$ $\mu$c/ml, and H-3 from 0.2 to 0.05 $\mu$c/ml. From this it is obvious that continuous surveillance is needed to determine levels of discharge as a function of downstream water use. Where water is used for irrigation, the various soil types should be sampled to determine exchange and adsorption of specific radionuclides

and analyses should be made of the crops growing in this area to measure uptake. This is taking on more significance in view of recent findings of higher uptake by plants from the water environment than from the soil environment.

With the extent of mobile reactors, special provisions will have to be made for analyses of estuarine and marine waters and associated biota.

In the case of reactor failures or accidents, the analyses required may be similar to those indicated for fuel reprocessing plants. The comments relating to the release of iodine during chemical reprocessing of fuel elements apply equally well to the case of reactor failures as was indicated during the Windscale reactor accident. Early monitoring and control involved the determination of iodine in a variety of environmental media.

Fuel Reprocessing Plants

When a spent reactor fuel element is dissolved in nitric acid or other medium at the beginning of chemical processing for the recovery of the unfissioned fuel, those fission products that are gaseous under the conditions employed -- chiefly iodine and the inert gases krypton and xenon -- will be released in the off-gas stream. If the fuel elements are cooled for short periods after removal from the reactor and prior to dissolution, large quantities of essentially pure isotopes of iodine will be released (7).

Unless iodine is very thoroughly scrubbed from the gas stream before release to the stack, the iodine will become a distinct radiological hazard to people working at short diffusion distances from the stack, both inside and outside the plant area.

The iodine released, being in either gaseous or particulate form, may be inhaled or pose an ingestion hazard due to the deposition on vegetation and consumption by animals or man. Extensive monitoring of vegetation and animal thyroids is carried out in the vicinity of fuel reprocessing plants to maintain surveillance over this particular radionuclide. It is for this reason that there is such widespread interest in a field type iodine sampler which will collect and detect iodine at low concentration, will be low in cost to encourage installation at a large number of sampling stations, and will be used only once and discarded since decontamination will be difficult if not impractical (7).

Milk obtained from cattle feeding in the vicinity of chemical reprocessing plants releasing radio-iodine may show substantial levels of this radionuclide.

Again citing the experience of Hanford, the suggestion has been made of reducing the MPC values for I-131 in air from $3 \times 10^{-9}$ to $3 \times 10^{-13}$ $\mu c/ml$ and H-3 from $2 \times 10^{-5}$ to $3 \times 10^{-6}$ $\mu c/ml$. They (6) have also suggested the introduction of a level for iodine-131 in vegetation equal to $1 \times 10^{-5}$ $\mu c/g$.

Liquid wastes from fuel reprocessing plants may be divided into two categories: high level and low level. Because of their recognized hazard, every effort is made to control high level wastes and to prevent their release into the environment. The only method of waste handling practiced for these wastes is storage. It is considered a temporary measure because little information is available on the long-term effects of radiation on the corrosion characteristics and structural integrity of the storage tank. Low level wastes are discharged into the environment and their effects must be evaluated.

Spent Radionuclides

Radionuclides are widely used in hospitals for diagnosis, therapy, and medical research. In diagnosis and therapy they may be used in gaseous, liquid, or solid form, and may be taken internally or used externally as solid sources. Radioactivity, in the form of spent solutions or body discharges may have to be released as wastes. Generally, because the materials are of short half-life, they may be stored for decay or diluted and discharged into the hospital sewerage system. On the basis of the quantities discharged at present, the latter method poses no particular environmental hazard. Obviously, solid sources will not be disposed of indiscriminately but will be returned to the manufacturer or to the atomic energy authority for disposal.

In medical or biological research, in addition to liquid wastes, we have the problem of solid waste disposal, including such materials as straw bedding, cage cleanings, and animal carcasses. These are disposed of generally by incineration. The waste gases which result should be monitored along with the residual ash. The latter is packaged prior to disposal by land or ocean burial. Gross activity measurements should suffice for most hospital operations. Laundering of contaminated clothing and other articles should take place after monitoring of the material to determine its radiation level or special facilities and techniques should be provided for their handling.

Similar comments would relate to the release of radioactive materials following research in industry or agriculture. The variety of radionuclides released would be greater, and they may be of longer half-life. Long-lived radionuclides should not be released into the environment but should be stored for reduction to a solid state and incorporation in some medium like concrete before disposal in suitable containers by burial on land or in the ocean.

Fallout

Nuclear tests have resulted in the widespread release of radioactive materials, some of which are deposited close to their site of formation; others such as strontium-90 and cesium-137 are carried into the stratosphere from which they may be deposited slowly over large areas distant from the point of detonation.

Fallout is also measured in relation to normal background (natural radioactivity) and levels of radioactivity associated with atomic plant operations. Thus, to measure the real contribution of radioactivity to the environment from such operations, the amount contributed by fallout must be known and corrections made for it. In many instances, it is difficult to determine the level of activity discharged from some of our nuclear plants because of the masking effect of fallout.

Solid Wastes

At the present time, solid wastes which originate from a variety of nuclear operations may be buried in the ground, either directly or following placement in suitable containers. The problem is one of monitoring to prevent external exposure to the personnel operating the burial ground and to minimize the possible contamination of ground waters which may be traversing the burial site. The external radiation levels are controlled by providing sufficient shielding between the source of radioactivity and the ground surface. Ground water levels of activity are determined by a series of monitoring wells which surround the burial facility. Where such wells are not present, it may be possible to get some idea of the movement of radioactive materials by taking soil samples to various depths or by taking samples of vegetation in the vicinity and noting the levels of activity in these samples.

Sea Disposal

Where local conditions permit, radioactive materials may be discharged directly into the sea. The best example of such practice is at Windscale where low level wastes are discharged into the Irish Sea. In this case specific analyses are carried out on sea water, fish nets and other fishing paraphernalia, sea sand, fish, and seaweed. The accumulation of ruthenium by the latter form represents the controlling factor as to the quantities of radioactivity that may be released to this particular environment. In other cases of sea disposal, the material is discharged in packaged form usually in the form of concrete monoliths contained in steel drums which should erode slowly, consequently there should be an extremely slow release of radioactivity into the environment.

Hazard Evaluation Reports

A means of control exerted by the AEC in terms of the location of nuclear power facilities is that of the hazard evaluation report. The purpose of this report is to indicate the possible degree of hazard resulting from the failure of a reactor facility or its appurtenances in a given area. The hazard summary reports includes information on the following items in relation to the site: geography, location, population, industrial development, agricultural development, wild life, meteorology, geology, hydrology, and seismology. Subsequent sections include information on safety provisions, operation, monitoring, waste disposal practices, safety and accident evaluations in case of reactor or other component failures, and public relations provisions.

AEC Experience in Radiation Exposure

The efforts of the Atomic Energy Commission and its predecessors in controlling occupational radiation exposure are highly commendable. In eleven years between August 1, 1945 and July 3, 1956 there were 16 radiation accidents in which 69 persons were over-exposed to radiation. In eight cases, only one person was involved. Of the 69 exposed, two died, one each in 1945 and 1946. Of the remainder, 19 separate skin injuries and several exposures were considered to be minor. Data cited by the Atomic Energy Commission for the period 1947 to 1955 involving almost 200,000 personnel showed that 99.66 per cent of the total number of workers received less that 5 rem per year dose. During 1955 of a total number slightly in excess of 60,000 workers 99.45 per cent received less than 5 rem per year dose. It must be remembered that over much of this period the permissible limit of exposure was 15 rem per year, not the 5 rem which has been recommended during the past year. For those who are more interested in statistics on the actual exposure levels they are referred to January 1957 Report of the U. S. Atomic Energy Commission (8).

Summary

In summary, an effort has been made to show what is being done by the AEC, the PHS, and other Federal and local agencies to measure the amount of radioactivity contributed from a multiplicity of sources and

relate their data to potential public health implications. There is a need for more data of this nature, particularly in terms of the specific radionuclides present in food materials grown all over the nation and the world. With such information on hand, we shall be able to define with a greater degree of accuracy the public health implications of such radiation levels and to provide a better basis for developing more realistic maximum permissible concentration levels in a greater variety of environmental media.

## Literature Cited

1. Recommendations of the International Commissions on Radiological Protection (Revised December 1, 1954). Supplement 6. Brit. J. Radiology. Published by the British Institute of Radiology London (1955).

2. National Bureau of Standards Handbook 52 (1953). "Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water." Superintendent of Documents, U.S. Government Printing Office, Washington, D. C.

3. Standards for Protection Against Radiation. Title 10, Atomic Energy, Chapter 1 - Atomic Energy Commission Part 20. Federal Register, 22: No. 19 (January 29, 1957).

4. Harley, J. H., R. P. Hardy, G. A. Welford, I. B. Whitney, and M. Eisenbud. Summary of Analytical Results from the Health and Safety Laboratory Strontium Program to June 1956. AEC Document No. NYO-4751, 36 pp. (1956).

5. Libby, V. F. Radioactive Strontium Fallout. Prec. Natl. Acad. Sciences, 42(6):365 (1956).

6. McCullough, C. Rogers, Editor. "Safety Aspects of Nuclear Reactors." Page 112. D. Van Nostrand Company, Inc., Princeton, New Jersey (1957).

7. Sill, C. W. and J. K. Flygave. A Sampling Cartridge and a Continuous Monitor for Determination of Radio-Iodine. Idaho Operations Office, 8 pp. mimeographed.

8. U. S. Atomic Energy Commission. Radiation Safety and Major Activities in the Atomic Energy Program - July-December, 1956. Superintendent of Documents, U. S. Printing Office, Washington, D. C. (January 1957).